AD-A049 163 UTAH UNIV SALT LAKE CITY ECOLOGY AND EPIZOOLOGY RESE--ETC F/G 6/5
STUDIES ON ECOLOGY OF Q FEVER IN NATIVE FAUNA IN THE GREAT SALT--ETC(U)
JUN 61 E D VEST, J B BUSHMAN, N J MARCHETTE DA-42-007-403-CML-427

UNCLASSIFIED ECOLOGY AND EPIZOOLOGY SE NL

| OF |
AD
A049163

END
DATE
FILMED
2-78
DDC

STUDIES ON ECOLOGY OF Q FEVER IN NATIVE FAUNA

in the

GREAT SALT LAKE DESERT

SUMMARY PROGRESS REPORT

E. DEAN VEST, JOHN B. BUSHMAN, NYVEN J. MARCHETTE, DALE D. PARKER,
D. ELMER JOHNSON, DAVID L. LUNDGREN, EVERETT L. MORSE,
ROBERT W. SIDWELL, AND BERT D. THORPE

Institute of Environmental Biological Research
Ecology and Epizoology Series No. 66*

June 30, 1961

* Supported by Dugway Proving Ground Contract No. DA-42-007-403-CML-427,
with the University of Utah

PRESUMPTIVE SAFETY REPORT

(6) STUDIES ON ECOLOGY OF Q FEVER IN NATIVE FAUNA

in the

GREAT SALT LAKE DESERT,

---

(9) SUMMARY PROGRESS REPORT,

(10) E. Dean Vest, John B. Bushman, Nyven J. Marchette, Dale D. Parker, D. Elmer Johnson, David L. Lundgren, Everett L. Morse, Robert W. Sidwell, and Bert D. Thorpe

---

(14) Institute of Environmental Biological Research
Ecology and Epizoology Series No. 66

(11) 30 June 1961

(12) 40p.

---

(15) *Supported by Dugway Proving Ground Contract No. DA-42-007-403-CML-427 with the University of Utah.

INTRODUCTION

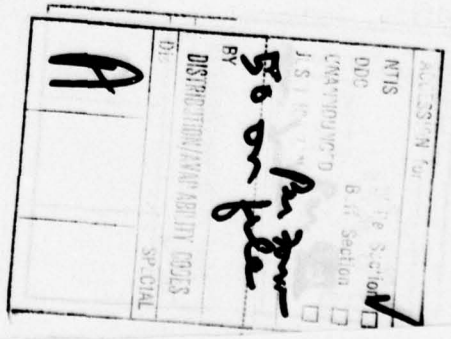
This report contains the results of field and laboratory studies on the rickettsial disease, Q fever, concerning susceptibility of native mammalian species, vector potential of ectoparasite arthropods, and incidence in the wildlife indigenous to areas of the Great Salt Lake Desert of Utah and Nevada.

The conclusions drawn are presumptive since they are based solely upon data from controlled laboratory experiments, disease surveys, and the work of others as reported in the literature. This information, however, is rather extensive in nature and yields pertinent data regarding the probable epizoology of Q fever in the wildlife of this area.

The disease survey methods used in these studies are described in a report, "Standard Methods for Examination of Samples of Wildlife Tissues and Wild, Domestic and Human Serum", University of Utah, Epizoology Diagnostic Laboratory, September 22, 1959. The experimental methods used are described in the Annual Summary Progress Report, Ecology and Epizoology, for 1959.

LITERATURE REVIEW

Q fever was first recognized in 1935 as a new and discrete disease of man in Australia (Derrick, 1937). In the same year, a filter-passing organism was discovered in the Rocky Mountain wood tick, Dermacentor andersonii, by Davis and Cox (1938), and it subsequently proved to be identical to the agent causing Q fever in Australia (Dyer, 1939). It is possible, however, that this agent was present in the United States at least as early as 1926 when Noguchi (1926) described a very similar organism recovered from D. andersoni collected in Montana, 60 miles from the site of the original isolation of Coxiella burnetii (Cox, 1938).



The first recognized case of Q fever in man in the United States occurred in Montana in 1941 (Hesdorfer and Duffaloe, 1941). This report was soon followed by accounts of human Q fever outbreaks in Amarillo, Texas (Irons et al, 1946); Chicago, Illinois (Shepard, 1947); and Los Angeles, California (Young, 1948). These cases usually could be directly associated with livestock. In 1949 a serological survey of human sera from many areas indicated that Q fever occurred in low incidence throughout the country (Strauss and Sulkin, 1949). Subsequent studies have supported this conclusion. Luoto (1960) reported that Q fever occurs in cattle throughout the United States.

Until recently, considerably more effort has been expended studying the incidence and distribution of Q fever in livestock and humans than in wildlife. An early study on Moreton Island, off the coast of Australia, presented evidence for a simple cycle of Q fever maintained in bandicoots, Isodon torosus, and their ticks, Haemaphysalis humerosa (Derrick and Smith, 1939), but early surveys of wild animals elsewhere were not so successful. Parker et al, (1948) tested the sera of several hundred wild vertebrates, but could demonstrate antibody against C. burnetii in only one animal, a porcupine (Erethizon epizanthum epizanthum). No evidence of Q fever was found in wild mammals or birds in England collected in an endemic area (Stoker and Marmion, 1955a). More recently, however, there have been numerous reports of evidence of Q fever in wild vertebrates throughout the world (Table 1), culminating finally in the isolation of C. burnetii from wild mammals in Utah, as a result of a large scale survey involving several thousand specimens (Stoenner et al, 1958).

From these discoveries, the probable existence of a C. burnetii cycle among wildlife, independent of the domestic animal ecological complex in the United States, was suggested by Stoenner et al (1959). In other parts of the world

this certainly seems to be the case. Natural Q fever infection has been reported in 68 species of wild vertebrates from five continents (Table 1). Rodents and rabbits are most often involved, but birds are occasionally infected, and in one case an antelope was reported to have suffered from a naturally acquired Q fever infection.

Biting arthropods are likewise well represented among the naturally infected wildlife. Coxiella burnetii has been isolated from at least 31 species of ticks, two species of lice, and two of mites. Some, but not all, of these arthropods have been shown experimentally to be capable vectors of the rickettsiae (Table 2).

On the laboratory level, C. burnetii has been shown in one study to persist in guinea pigs, principally in the spleen and kidney, 40-110 days after defervescence, depending upon the strain of organism used (Parker and Steinhaus, 1943). In another study the organisms persisted for up to 526 days after defervescence in guinea pigs (Reczko, 1950). In laboratory mice, C. burnetii persists for up to 80 days in the kidneys (DeMattia et al, 1952); and in white rats, urine was infective from the 13th-38th day after infection (Syrucek and Sobeslavsky, 1956).

Parker et al, (1948) tested seven species of wild rodents, one species of cottontail rabbit, and two species of birds, and found all to be susceptible to experimental Q fever. Bandicoots (Derrick et al, 1939) and nine other species of Australian bush animals were susceptible to intraperitoneal infection with C. burnetii, but in all cases the infection was mild, often inapparent, and none of the animals died (Derrick et al, 1940). Experimental Q fever in the forest mouse of Czechoslovakia produced no noticeable illness, but a rickettsemia was present from the first through the 12th day (Rehn,

1958). Zhmaeva and Pchelkina (1957) reported lemmings to be readily infected with C. burnetii. In Morocco, Meriones shawi, Xerus getulus and Aetichinus algirus, were reported to be susceptible to experimental infection (Blanc et al, 1947b). In one study on foxes inoculated subcutaneously, no apparent illness resulted, no rickettsemia was detected, and no isolations were made from tissues examined 30 days after inoculation. Complement fixing antibody against C. burnetii, however, rose to a significant titer within 15 days (Rehn, 1958).

Parker et al, (1948) and Sobeslavsky and Syrucek (1959) reported some birds to be susceptible to experimental Q fever; the latter investigators reporting the isolation of C. burnetii from the spleen of chickens one year after infection, and from the ovaries of second generation chickens hatched from eggs laid by the experimentally infected hens. Babudieri and Moscovici (1952) recovered C. burnetii from the kidney of pigeons six weeks after intraperitoneal and oral exposure.

TABLE 1. Wild animals naturally infected with Coxiella burnetii
Wild animals naturally infected with C. burnetii as indicated by positive serology or by isolation of organisms from tissues.

Species	Common Name	Country	Diagnosis	Pertinent reference
		AVES		
Buteoninae				
____ ____	Eagle	Russia	S	Borisov et al., 1959
Picidae				
Emberiza citrinella	Yellowhammer	Czechoslovakia	S	Syrucek and Raska, 1956
Dryobates major	Great spotted woodpecker	Czechoslovakia	S	Syrucek and Raska, 1956
Alanidae				
____ ____	Lark	Russia	S	Borisov et al., 1959
Hirundinidae				
Hirundo rustica	Swallow	Czechoslovakia	S	Syrucek and Raska, 1956
Delichon urbica	House martin	Czechoslovakia	S	Syrucek and Raska, 1956
Corvidae				
____ ____	Crow	Russia	S	Borisov et al., 1959
Paridae				
Parus major	Great tit	Czechoslovakia	S	Syrucek and Raska, 1956
Troglodytidae				
Troglodytes troglodytes	Wren	Czechoslovakia	S	Syrucek and Raska, 1956
Motacillidae				
Motacilla alba	White wagtail	Czechoslovakia	I,S	Raska and Syrucek, 1956; Syrucek and Raska, 1956; Syrucek et al., 1955

S = Evidence of infection determined serologically, only.
I = Evidence of infection determined by isolation of Coxiella burnetii.
__ = Information not given in cited reference.

TABLE 1 (continued)

		AVES (cont'd)		
Compsothlypidae				
Phoenicurus phoenicurus	Redstart	Czechoslovakia	I	Syrucek et al., 1955; Syrucek and Raska, 1956
P. ochruros	Black redstart	Czechoslovakia	S	Syrucek and Raska, 1956
Plocediae				
Passer montanus pallidus	Sparrow	Czechoslovakia	I,S	Zhmaeva et al., 1956; Syrucek and Raska, 1956
P. domesticus	House sparrow	Czechoslovakia	S	Syrucek and Raska, 1956
Fringillidae				
Fringilla coelebs	Chaffinch	Czechoslovakia	S	Syrucek and Raska, 1956
Chloris chloris	Green finch	Czechoslovakia	S	Syrucek and Raska, 1956
		MAMMALIA		
		Marsupialia		
Hydromys chrysogaster	Water rat	Australia	S	Freeman et al., 1940
Isodon torosus	Australian bandicoot	Australia	I	Derrick & Smith, 1940; Freeman et al., 1940
Macropus major	Gray kangaroo	Australia	I,S	Pope et al., 1960
Megaleia rufa	Red kangaroo	Australia	S	Pope et al., 1960
Aepyptymmus refescues	Rat kangaroo	Australia	S	Cited by: Parker et al.,1948
		Insectivora		
Sericidae				
Sorex araneus	Common mouse shrew	Czechoslovakia	I	Rehn and Radvin, 1959
S. minutus	Pygmy shrew	Czechoslovakia	I	Syrucek et al., 1957

S = Evidence of infection determined serologically, only
I = Evidence of infection determined by isolation of *Coxiella burnetii*
__ = Information not given in cited reference.

TABLE 1 (Continued)

MAMMALIA (cont'd)

		Insectivora		
Erinaceidae				
Erinaceous europaeus	Hedgehog	Roumania	I,S	Zarnea et al., 1959
		Chiroptera		
Vespertilionidae				
Eptesicus isobellinus	Bat	Morocco	I	Blanc and Bruneau, 1957
_____ _____	Bat	Russia	I	Lisunkina, 1960b
		Carnivora		
Mustelidae				
_____ _____	White weasel	Russia	S	Zhmaeva et al., 1956
		Rodentia		
Sciuridae				
Eutamias minimus	Least chipmunk	Utah (U.S.)	S	Stoenner et al., 1959
_____ _____	Steppe marmot	Russia	S	Zhmaeva et al., 1959
Citellus pygmaeus	Suslik	Russia	I	Zhmaeva & Pchelkina, 1957
Spermophilopsis leptodactylus	_____		II(S)	Zhmaeva et al., 1955
Heteromyidae				
Rhombomys epimus	Gerbil	Russia	I (S?)	Zhmaeva et al., 1955
Dipodomys microps	Chisel-toothed kangaroo rat	Utah (U.S.)	I,S	Stoenner et al., 1959
D. ordii	Ord kangaroo rat	Utah (U.S.)	I,S	Stoenner et al., 1959
Perognathus longimembris	Little pocket mouse	Utah (U.S.)	I	Lundgren & Sidwell (Unpub)
Meriones shawi	Gerbil	Morocco	I	Blanc et al., 1947a
Cricetidae				
Onychomys leucogaster	Northern grasshopper mouse	Utah (U.S.)	S	Stoenner et al., 1959
Apodemus sylvaticus	Forest mouse	Morocco	I	Blanc and Bruneau, 1956a
Clethrionomys glareolus	Red-backed mouse	Czechoslovakia	I,S	Raska et al., 1956
C. rufocanus	Wood vole	Russia	I	Nikhinson et al., 1958
C. rutilus	Wood vole	Russia	I	Nikhinson et al., 1958
Eliomys querclinus	Spanish dormouse	Spain	I,S	Perez Gallardo et al., 1952

S = Evidence of infection determined serologically, only
I = Evidence of infection determined by isolation of *Coxiella burnetii*
__ = Information not given in cited reference

TABLE 1 (continued)

Rodentia (cont'd)				
Cricetidae (cont'd)				
Lemniscomys barbarus		Morocco	I	Blanc and Bruneau, 1956a
L. striatus	Striped mouse	Kenya	I,S	Heisch, 1960
Peromyscus maniculatus	Deer mouse	Utah (U.S.)	I (S?)	Stoenner et al., 1959
Neotoma micropus	Wood rat	Texas (U.S.)	S	Irons et al., 1952
Cricetulus migratorius		Russia		Bekrimieov et al., 1956
____ ____	Common hamster	Russia	S	Zhmaeva et al., 1956
Apodemus flavicalis		Czechoslovakia	S	Raska and Syrucek, 1956
Microtus arvalis		Czechoslovakia	S	Raska et al., 1956
Arvalis terrestris		Czechoslovakia	S	Raska et al., 1956
____ ____	Red-tailed gerbil	Russia	S	Sterkhova and Akhundov, 1959
____ ____	Persian gerbil	Russia	S	Sterkhova and Akhundov, 1959
Muridae				
Mus musculus	House mouse	Czechoslovakia	I,S	Raska et al, 1956
Rattus culmorum youngi		Australia	S	Freeman et al., 1940
R. norvegicus	Norway rat	Czechoslovakia	I	Raska et al., 1956
____ ____	Grey rat	Russia	I	Sterkhova & Akhundov, 1959
Lagomorpha				
Leporidae				
Cryctolagus cuniculus	European gray rabbit	Central Europe	S	Blanc & Bruneau, 1953
____ ____	Mountain rabbit	Spain	I	Perez Gallardo et al., 1952
Lepus californicus	Black-tailed jack rabbit	Utah (U.S.)	S	Stoenner et al, 1959; and Lechleitner, 1959
L. europaeus	European hare	Czechoslovakia	S	Raska et al., 1956
____ ____	Zerboa hare	Russia	S	Zhmaeva et al., 1956
Artiodactyla				
Antilocapridae				
Antilope subgutturosa	Antelope	Russia	S	Zhmaeva and Pchelkina, 1957
Cervidae				
____ ____	Deer	Russia	S	Nikhinson et al., 1958
____ ____	Gazelle	Russia	S	Proreshnaia and Mishchenko

S = Evidence of infection determined serologically, only
I = Evidence of infection determined by isolation of *Coxiella burnetii*
__ = Information not given in cited reference

TABLE 2. Biting arthropods naturally infected with Coxiella burnetii

Biting arthropods naturally infected with C. burnetii as indicated by isolation of rickettsia. Those capable of transmitting C. burnetii experimentally indicated by an asterisk, with pertinent reference of transmission listed in footnote.

Species	Country	Pertinent reference of isolation	Hosts on which infected ticks were found
		TICKS	
Amblyomma americanum	Texas (U.S.)	Parker and Kohls, 1943	Goats, cattle, dogs
A. triguttatum	Australia	Pope et al., 1960	Kangaroos, goats, sheep
A. variegatum	Africa	Blanc et al., 1950	Buffaloes
Argas persicus	Russia	Lisunkina, 1960a	?
A. reflexus	Russia	Zhmaeva et al., 1955	Sparrows
*Dermacentor andersonii[1]	Montana (U.S.)	Davis and Cox, 1938	?
D. occidentalis	Australia	Cox, 1940	?
D. parumapertus	Utah (U.S.)	Stoenner et al., 1959	Jack rabbits
*Haemaphysalis humerosa	Australia	Smith & Derrick, 1940	Bandicoots
H. leachi	Africa	Giroud, 1951	Dogs, cows
H. leporis-palustris	Virginia (U.S.)	Kohls, 1948	Rabbits
H. punctata	Britain	Stoker and Marmion, 1955b	Sheep
Hyalomma anatolicum (excavatum)	Russia	Proreshnaia & Mishchenko, 1958	?
Hy. detritum	Russia	Zhmaeva et al., 1955	?
Hy. drosedarii	Africa	Blanc et al., 1948; and Taylor et al., 1952	Dromedaries
Hy. excavatum	Africa	Blanc & Bruneau 1956b; and Taylor et al., 1952	Rabbits, cattle
Hy. e. lysutanicum	Africa	Blanc et al., 1948; and Taylor et al., 1951	Gerbils
*Hy. marginatum[3]	Spain ?	Perez Gallardo, 1949	Calves
Hy. mauritanicum	Africa	Blanc and Bruneau, 1949	Cattle
* Hy. plumbeus[4]	Russia	Bektemirov et al., 1956	Domestic and wild animals
Hy. savitnyi	Spain, Africa	Parker et al., 1949; and Blanc et al., 1946	Sheep and goats

[1]Parker and Davis, 1938; [2]Smith, 1940; [3]Zhmaeva et al., 1955; [4]Zhmaeva et al., 1955.

TABLE 2 (continued)

		TICKS (cont'd)	
Ixodes cranulatus	Russia	Pchelkina et al., 1956	Polecat
I. dentatus	Virginia and New York (U.S.)	Kohls, 1948	Rabbits
*I. holocyclus[5]	Australia	Carley and Pope, 1953	?
I. ricinus	North Europe	Hengle et al., 1950	Dogs
Leeuwenhoekia major	Russia	Zhmaeva and Pchelkina	?
*Ornithodoros erraticus[6]	Africa	Blanc and Bruneau, 1955	?
Orn. lahorensis	Turkey	Payzin and Array, 1952	?
*Orn. Moubata[7]	Central Africa	Jadin, 1951	?
Orn. tartakocskyi	Russia	Zhmaeva and Pchelkina, 1957	?
Otobius megnini	U. S.	Jellison et al., 1956	Cattle
Rhipicephalus bursa	Russia	Bektimirov et al., 1956	Domestic & wild animals
* R. sanguineus[8]	Arizona (U.S.)	Parker and Sussman, 1949	Dogs
	Italy	Mantovani & Benazzi, 1953; and Perez Gallardo et al., 1949	Dormice
		LICE	
Ornithomyis biloba	Czechoslovakia	Syrucek and Raska, 1956	?
Pediculus corporis	Africa	Giroud, 1951	?
		MITES	
Dermanyssus passerinus	Russia	Zhmaeva et al., 1955	Sparrows
Steatonyssus viator	Russia	Zhmaeva et al., 1955	?

[5]Smith, 1941; [6]Blanc and Bruneau, 1956c; [7]Davis, 1943; [8]Smith, 1941.

RESULTS

1 - Mammalian susceptibility to parenteral inoculation: In the first laboratory experiment it was found that 11 species of rodents, Peromyscus maniculatus, P. truei, P. crinitus, Citellus leucurus, Perognathus parvus, Dipodomys ordii, D. microps, Reithrodontomys megalotis, Onychomys leucogaster, Neotoma lepida, and Microtus montanus, were highly susceptible to C. burnetii (AD strain), administered by parenteral inoculation, as determined by 28-day complement fixing antibody response. Infection was seldom lethal, but the organism reproduced rapidly in the tissues of all species. The ID_{50} in all rodent species tested was approximately 10^1 to 10^3 guinea pig ID_{50}s.

In a second experiment studying the susceptibility of rodents, animals of 5 species, D. ordii, M. montanus, N. lepida, P. maniculatus and P. truei, were investigated further to determine a criterion of infection which would yield the most reliable ID_{50}. Criteria of infection employed were splenomegaly (enlargement at least 2 x normal), tissue infectivity (as determined by subinoculating guinea pigs with tissue pool homogenates), and complement fixing antibody response to egg-adapted (Phase II) antigen, all at 28 days after injection. Guinea pigs and white mice were investigated similarly to provide comparative data.

At 28 days, spleen enlargement of some degree was exhibited in all species of wild animals tested, but gross enlargement was generally noted only in those animals receiving comparatively concentrated inocula. Splenomegaly was absent in all guinea pigs at this time. Definite complement fixing antibody response was noted in animals of each species tested; titers usually ranging from 1:16 to greater than 1:256 in P. maniculatus, P. truei and N. lepida; 1:16 to 1:128 in D. ordii; 1:128 to greater than 1:256 in

M. montanus and white mice. Non-specific antibody titers of 1:8 to 1:16 were observed in occasional P. maniculatus, P. truei, and N. lepida normal controls, consequently only titers of 1:32 or greater were considered an indication of infection in these animals. The presence of infectious numbers of C. burnetii in pools of tissue of all animal species was demonstrated 28 days after injection. Microscopic examination of stained tissue smears seldom revealed rickettsiae.

Comparative ID_{50s} for this portion of the investigation are indicated in Table 3. All rodent species had ID_{50s} which were in general about 10^1 to 10^2 guinea pig or white mouse ID_{50s}.

2 - Pathogenesis (Rickettsemia and Carrier State). Coxiella burnetii persisted in the blood stream of P. maniculatus, N. lepida, and Sylvilagus audubonii for at least 3 weeks following subcutaneous inoculation.

Coxiella burnetii was demonstrated in the blood stream of coyote pups for up to 7 weeks after subcutaneous inoculation with 10^9 guinea pig ID_{50s}, and in the blood stream of bobcats, Lynx rufus, for up to nine days after similar exposure. The organism persisted for at least three weeks in the spleens of bobcats.

The organism persisted for 12 to 36 weeks in the tissues of P. maniculatus, P. truei, N. lepida, M. montanus, D. ordii, and S. audubonii. Kidney, spleen, and liver were particularly infected.

3 - Mammalian susceptibility to field aerosol. The effect of an aerosol of C. burnetii on 7 species of wild rodents exposed under field conditions was studied. Twenty-five groups of 11 animals each were placed at predetermined positions 3/4 to 11 miles from the source of the aerosol. Each group was

TABLE 3. Susceptibility of laboratory animals and wild rodents to intraperitoneal infection with AD strain, Coxiella burnetii. Data presented as ID_{50},[5] calculated by the Reed & Muench method (1938), and standard error, estimated by the method described by Pizzi (1950), according to each criterion for determining infection.

Type of Animal	ID_{50} and S. E. - Fever Response[1]	ID_{50} and S. E. - Antibody Response[2]	ID_{50} and S. E. - Tissue Infection[3]	ID_{50} and S. E. - Splenomegaly[4]
Cavia cobaya Guinea pig	$10^{-9.1}$ $10^{-8.9}$ to $10^{-9.3}$	$10^{-9.3}$ $10^{-9.1}$ to $10^{-9.5}$	$10^{-9.2}$ $10^{-9.0}$ to $10^{-9.4}$	No response at dilutions employed
Dipodomys ordii Ord kangaroo rat	Not determined	(10^{-9} to 10^{-10})	(10^{-9} to 10^{-10})	$10^{-7.8}$ $10^{-7.4}$ to $10^{-8.2}$
Microtus montanus Montane meadow mouse	Not determined	$10^{-8.6}$ $10^{-8.4}$ to $10^{-8.9}$	$10^{-8.3}$ $10^{-8.2}$ to $10^{-8.4}$	$10^{-8.2}$ $10^{-7.9}$ to $10^{-8.4}$
Mus musculus White mouse	Not determined	$10^{-9.3}$ $10^{-8.9}$ to $10^{-9.7}$	$10^{-8.6}$ $10^{-8.2}$ to $10^{-8.6}$	$10^{-8.2}$ $10^{-8.9}$ to $10^{-9.6}$
Neotoma lepida Desert wood rat	Not determined	10-8.5 $10^{-8.3}$ to $10^{-8.7}$	10-8.4 $10^{-8.2}$ to $10^{-8.6}$	10-8.4 $10^{-8.2}$ to $10^{-8.6}$
Peromyscus maniculatus Deer mouse	Not determined	$10^{-8.3}$ $10^{-8.1}$ to $10^{-8.5}$	(10^{-6} to 10^{-8})	$10^{-7.4}$ $10^{-7.1}$ to $10^{-7.7}$
Peromyscus truei Pinyon mouse	Not determined	$10^{-8.3}$ $10^{-8.1}$ to $10^{-8.5}$	$10^{-8.3}$ $10^{-8.1}$ to $10^{-8.5}$	$10^{-8.3}$ $10^{-8.1}$ to $10^{-8.5}$

[1] A well-defined, sustained rise above 104,0°F.
[2] Phase II CF titers of 1:16 or greater in Ord kangaroo rats; 1:32 or greater in all other animals.
[3] Determined by 28-day Phase II CF titers in guinea pigs sub-inoculated with pooled homogenates of heart, kidney, liver, lung and spleen.
[4] At least 2 x normal.
[5] Expressed as dilutions of C. burnetii - egg yolk sac slurry.
( ) Insufficient data for calculation of ID_{50}.

composed of the following rodents: 3 deer mice, P. maniculatus; 1 canyon mouse, P. crinitus; 2 grasshopper mice, O. leucogaster; 2 Ord kangaroo rats, D. ordii; 1 chisel-toothed kangaroo rat, D. microps; 1 wood rat, N. lepida; and 1 antelope ground squirrel, C. leucurus.

An overall infection rate of 62% was recorded. Under field conditions the C. burnetii aerosol was highly infectious for native rodents. Individuals of each of the above species developed Q fever.

4. Mammalian antibody response. Three types of antibody to the AD strain of C. burnetii were studied with regard to time of formation, concentration and duration in intraperitoneally infected D. ordii, M. montanus, N. lepida, P. maniculatus and P. truei. Guinea pigs and white mice were also studied to provide comparative data. The types of antibody studied were Phase II complement fixing (CF) (detected using antigen prepared from egg-adapted rickettsiae); Phase I complement fixing (detected using antigen prepared from animal-adapted rickettsiae); and capillary tube (CT) agglutination antibody. Results are shown in Fig. 1. Phase II CF antibody was produced 1 to 2 weeks following infection in all species of animals tested, and peak titers were reached by 3 to 5 weeks. Phase I CF antibody and CT agglutination antibody were first demonstrated at 3 to 5 weeks and increased to peak titers 6 to 36 weeks after infection, depending upon animal species. In most animals, Phase II CF antibody titers were higher than Phase I CF or CT agglutination antibody titers. Antibody persistence was followed for 36 to 52 weeks, depending upon animal type. D. ordii produced little demonstrable Phase I CF or CT agglutination antibody.

The antibody response to formalin inactivated C. burnetii was studied in the previously named 5 species of wild rodents. This was undertaken in an attempt to relate antibody response to infection. Results are shown in Fig. 2.

MAMMALIAN ANTIBODY RESPONSES TO VIABLE Q FEVER RICKETTSIAE

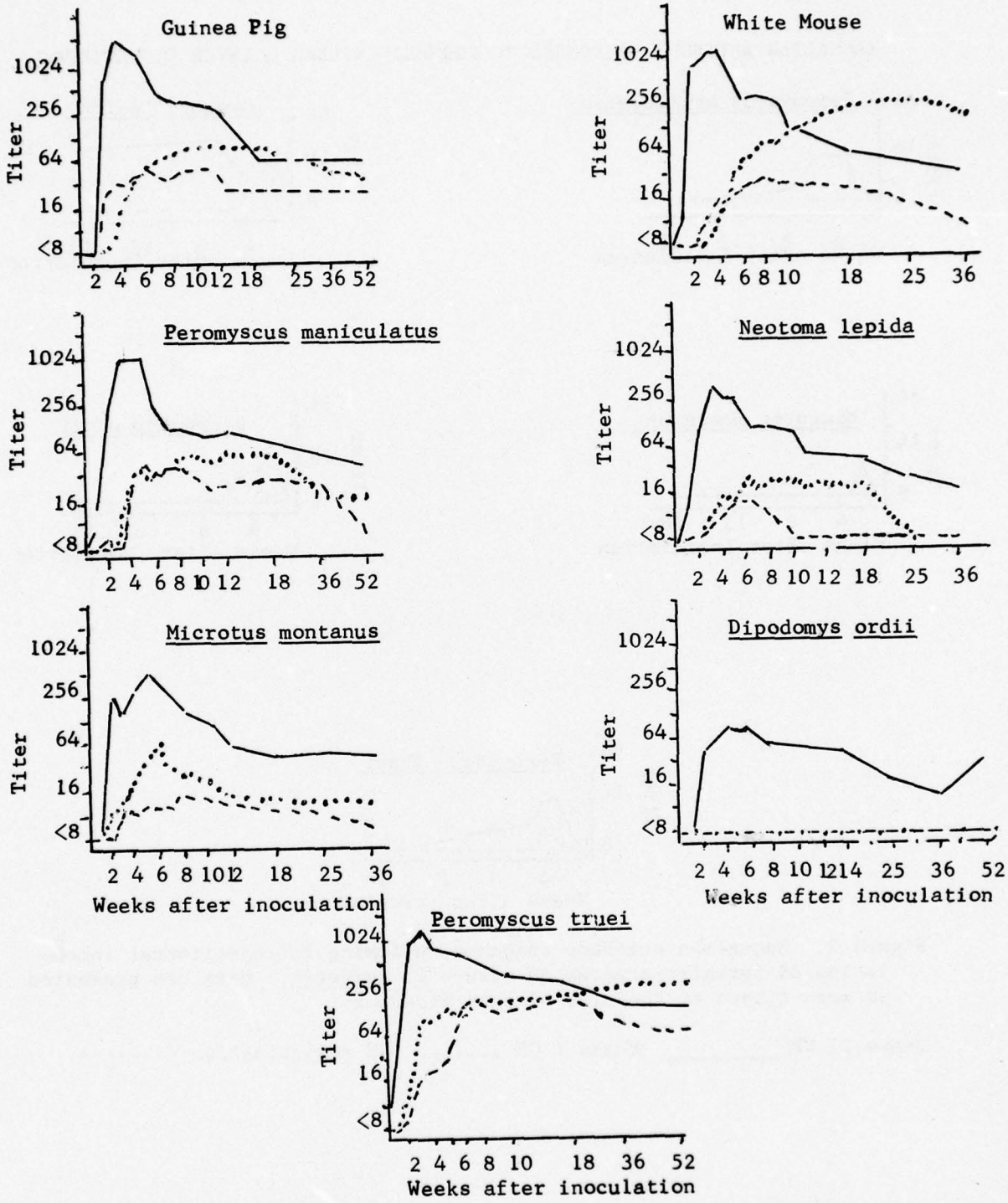


Figure 1. Mammalian antibody response following intraperitoneal injection of the AD strain C. burnetii. Data presented as mean titers at the time of each bleeding.
Phase II CF _____ Phase I CF ..... CT Agglutination --------

MAMMALIAN ANTIBODY RESPONSES TO FORMALIN KILLED Q FEVER RICKETTSIAE

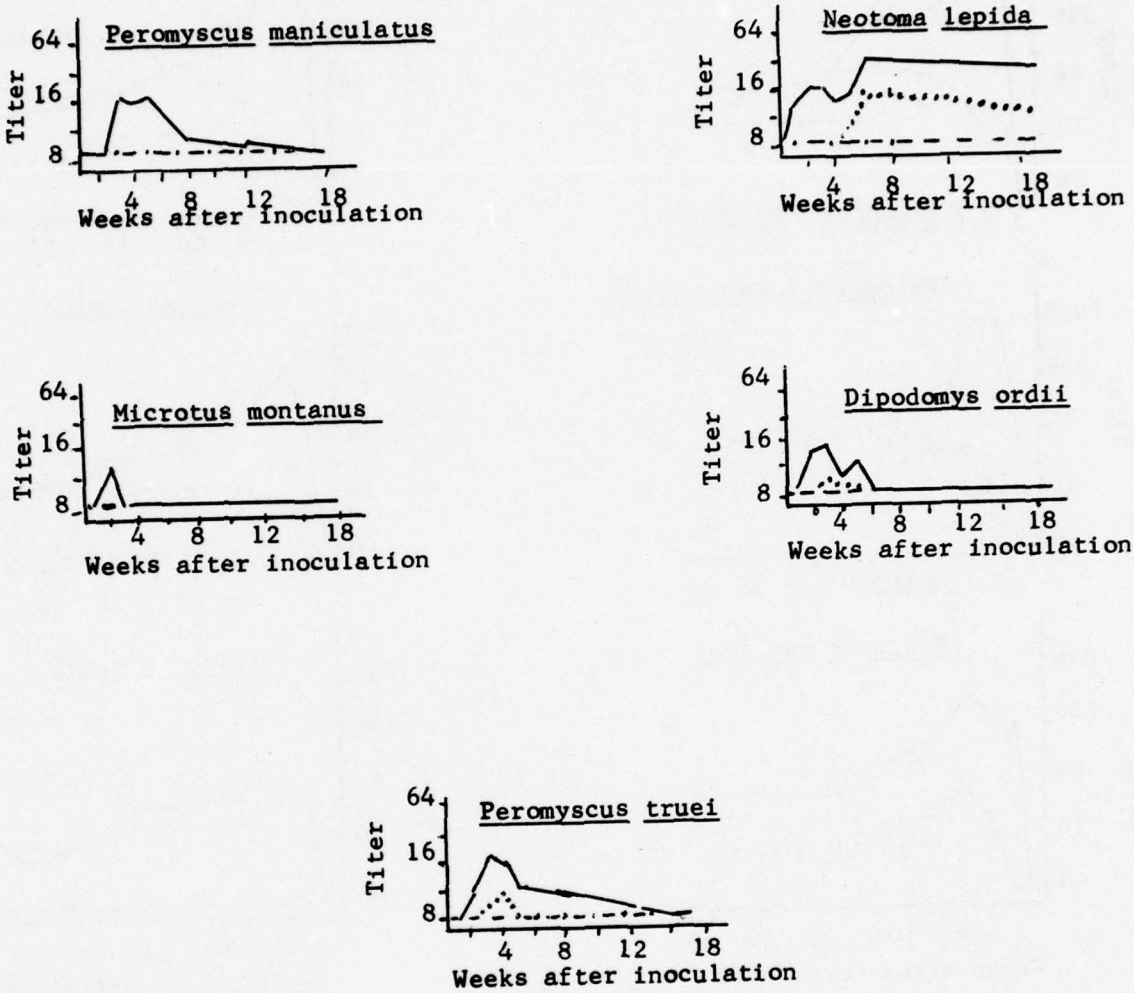


Figure 2. Mammalian antibody response following intraperitoneal inoculation of formalin-treated AD strain C. burnetii. Data are presented as mean titers at the time of each bleeding.

Phase II CF _____ Phase I CF ..... CT Agglutination --------

Low titers of Phase II CF antibody were produced in all rodent species. An occasional Phase I CF antibody titer was exhibited in sera from D. ordii, N. lepida, and P. truei. No agglutinating antibody could be detected.

5 - Experimental arthropod transmission. Ticks of three species, Ixodes kingi, Dermacentor parumapertus, and Ornithodoros hermsi, were found to be infected throughout their normal life. Currently, infected ticks held in our laboratory have remained infective for more than 200 days.

Both single and multiple-host ticks occur in this area. Multiple-host ticks attach to host animals only while feeding and then drop off to molt. Single-host ticks attach during the larval stage, molt to nymphs, engorge, drop off the host, molt to adults, mate, lay eggs, and die. They never reattach to a new host. Because of their habits, the single-host feeders would seem to be of little importance from an epizootiological standpoint because they are limited to a single host. Nevertheless, they cannot be completely ignored since they are readily eaten by rodents, and the infection may be transmitted in this manner. Some of these ticks have remained infective in our laboratory for as long as 10 days after death, and healthy rodents eating these dead ticks have become infected.

Because of the longevity and the nature of the life history of the ticks, transmission experiments are still in progress, and will not be completed until the ticks mature.

Three species of native fleas became infected after feeding on deer mice. Several groups of native fleas retained viable organisms up to three weeks after infection. Two species, Thrassis bacchi gladiolis and Orchopeas leucopus, became desiccated and died after 5 to 8 days at room

temperature. They lived longer (two to four weeks) when held at 4 to 12 C. Another species, O. sexdentatus, was not tested at room temperature to determine the longevity of the organisms, but remained infective for up to 17 days when held at 8 C. Uninfected controls lived longer under both temperature conditions than did those groups which carried the rickettsiae, indicating that the rickettsiae had a deleterious effect upon the fleas. Tests were conducted to determine if the organisms multiply in the fleas to the extent that they can be transmitted. In all experiments, native fleas failed to transmit Q fever organisms.

6 - Epizoological studies of Q fever. During the summer of 1954 a comprehensive study of diseases endemic to western Utah and eastern Nevada was undertaken by Ecological Research, University of Utah; and Rocky Mountain Laboratory, USPHS. The personnel of the former established the sample areas, studied the habitat, obtained samples and shipped them to the latter to examine for evidence of pathogenic organisms. This arrangement was continued until 1957, since when the entire study has been conducted by Ecological Research, University of Utah.

Since the basic objective of this study was to determine the ecology of disease in relation to Dugway Proving Ground (DPG), permanent sampling areas were located throughout DPG and in significant wildlife populations surrounding it. These permanent sampling areas were trapped systematically each year, and on the strength of this trapping, a basis was provided for comparative studies of the ecology of endemic disease organisms. Other areas were established beyond these permanent sampling areas to provide adequate controls, to supply additional information, and to aid in determining disease spread in relation to DPG. These latter areas were not sampled regularly, but rather only as information was needed.

From the summer of 1954 to the end of 1960, a total of 14,247 vertebrate wildlife specimens were collected from all sampling areas. An attempt was made to obtain approximately 2,000 samples per year in order to compare results. However, systematic trapping produced some variation from this number, probably due to population variations and other changing factors. Trapping in 1954 did not produce a complete annual sample since the program started during the summer of that year. From 1955 to 1960 annual samples ranged from a minimum of 1,782 in 1957 to a maximum of 2,860 in 1958. Essentially, these extremes represent a relatively uniform sampling technique, but indicate a variable population. The evidence of Q fever in these wildlife specimens was grouped according to whether it was found in mammalian tissue pools, ectoparasite pools, or individual serum samples. The incidence of infection, in relation to host species and area, is indicated to provide information regarding the ecology of the organism.

Q fever positive tissues were found in wildlife in 1955, and in 1957 through 1960 (Table 4). The first tissues infected with Q fever rickettsiae were taken from deer mice captured on Little Davis Mountain and Camelback Mountain, located near the east and south border of the Proving Ground, respectively. It is of some interest to note that both locations are adjacent to sheep range and bedding grounds, certainly not eliminating the possibility of infection from this source. Both areas are only a short distance from the locus of the first seropositive jack rabbit collected one year earlier just inside the Proving Ground fence, near the southeast border.

All samples tested were negative in 1956. In 1957 samples with positive tissue were obtained from 3 areas. One of these samples was collected 40 miles west of DGP; one near the northeast border, and the other in the proximity of the center of DPG. Of the three areas in which positive tissue

TABLE 4. INCIDENCE OF Q FEVER IN WILDLIFE TISSUE ACCORDING TO AREA. Areas from which wildlife specimens were collected that exhibited evidance of Coxiella burnetii in the tissues. These are listed as the number positive over the number collected for each year.

Area	1954**	1955	1956	1957	1958	1959	1960
Callao		0/132	0/352	1/225	0/175	3/371	2/145
Camelback Mountain		1/55	0/214	0/7	0/91	3/371	8/154
CD 22			0/19		1/110	0/20	0/68
Deep Creek	0/18				0/9	0/16	2/49
Dugway Mountain	0/16					0/23	0/60
Dugway Valley		0/2			1/82	2/72	0/31
Fish Springs	0/128	0/102	0/71	0/113	1/52	1/50	4/86
Gold Hill	0/137	0/140	0/351	0/293	0/216	3/179	2/104
Government Creek	0/9	0/113	0/121	0/138	1/34	4/295	3/183
Granite Mountain	0/210	0/120	0/8		0/47	0/38	0/49
Johnson Pass		0/72		0/19	0/85	0/107	0/2
Little Davis Mountain		1/379	0/222	0/195	0/107	0/122	0/56
Lookout Pass						0/47	0/92
North Skull Valley			0/90	0/23	0/244	0/132	0/136
Old River Bed			0/2	0/43	0/296	0/104	0/56
South Cedar Mountain		0/461	0/18	2/237	2/446	0/49	3/253
South Skull Valley	0/19	0/288	0/97	0/218	0/15	0/29	3/72
Test Grid	0/60	0/10	0/74	3/186	1/125	0/20	3/67
Trout Creek		0/23		0/5		1/34	2/239
Vernon		0/38			0/60	0/51	0/42
Wendover					4/582	1/329	0/250
Wig Mountain	0/131	0/84	0/293	0/80	0/54	0/113	0/56
Wildcat Mountain					0/30		0/38
Other areas*						0/196	0/101
Totals	0/278	2/2019	0/1392	6/1782	11/2860	15/2481	32/2389

** Collections were made for the last half of this year, only.
* Includes Duchesne, Grouse Creek and Logan.

samples were recorded, the first two were obtained near or on domestic animal range land. The other positive tissue was obtained from a jack rabbit. Since 1957, positive tissues have been taken from animals in 13 of the 23 regular sample areas. It can be noted that the mountain populations to the west, north, and east, namely: Granite, Wildcat, and Wig Mountain, did not contain detectable Q fever rickettsiae.

Thirty-three species of wildlife were sampled. Of these, the study of 14 species produced evidence of Q fever rickettsiae. Only 13 of the 33 species collected were obtained in numbers of more than 100 individuals during the entire 7-year period. Of these 13 more abundant species, positive tissues were found in individuals of 10. This indicates rather widespread distribution of Q fever among the more abundant wildlife populace. Species of mammals examined for Q fever rickettsiae are listed in Table 5.

Complement fixing (CF) antibodies against Q fever rickettsiae (Table 6) were first found in serum from a jack rabbit collected in 1954 on the southeast border of DPG. The following year Q fever antibodies were found in the same wildlife species collected from the same area. In 1956 none of the sera collected exhibited Q fever CF antibodies. In 1957, however, three new areas housed animals whose sera exhibited these antibodies. Two of these areas were the same as those from which Q fever positive wildlife tissues were recovered. The other was the Old River Bed region near the south border of DPG. In 1958, of 19 areas from which 10 or more animals were taken, 17 produced wildlife that contained sera with CF titers. Complement fixation titers were demonstrated in as many as 8 of 73 samples tested in some of these areas. In 1959, 20 of the 23 areas sampled had positive sera. Of the areas where a reasonable number of samples were taken (more than 10) Trout

TABLE 5. SPECIES WITH Q FEVER POSITIVE TISSUES. Wildlife species exhibiting Coxiella burnetii in their tissues. Data are expressed as the number positive over the number collected.

Species	1954	1955	1956	1957	1958	1959	1960
Lepus californicus	0/163	0/410	0/546	1/353	1/213	2/442	8/372
Sylvilagus nuttallii		0/2	0/1		0/1		0/1
S. audubonii	0/6	0/5	0/5		0/7		2/35
Citellus townsendii		0/4					1/5
C. variegatus		0/1					0/2
C. leucurus	0/16	0/175	0/34	0/82	1/181	2/221	0/261
Eutamias minimus	0/9	0/14	0/16	0/19	0/44	0/47	1/23
E. dorsalis	0/6	0/17	0/1	0/3	9/11	0/20	0/34
Thomomys bottae				0/1	0/1		1/1
Perognathus longimembris	0/2	0/16	0/3	0/11	0/87	2/85	0/68
P. parvus	0/6	0/37	0/29	0/36	0/115	0/89	0/124
P. formosus	0/152	0/21	0/8	0/32	0/70	0/62	1/121
Microdipodops megacephalus				0/4	0/15	0/5	0/10
Dipodomys ordii	0/67	0/358	0/78	1/422	3/560	1/250	1/236
D. microps	0/42	0/107	0/114	4/235	3/361	4/249	16/339
Reithrodontomys megalotis	0/24	0/48	0/85	0/42	0/60	0/106	0/52
Peromyscus crinitus	0/105	0/45	0/32	0/42	0/40	0/80	0/27
P. maniculatus	0/74	2/607	0/894	0/396	0/693	0/611	1/1541
P. truei	0/7	0/25	0/19	0/12	0/27	1/134	0/73
Onychomys leucogaster	0/4	0/18		0/14	0/10	0/8	0/6
Neotoma lepida	0/45	0/104	0/49	0/71	3/86	0/46	0/53
N. cinerea				0/2	0/1	0/1	
Ondatra zibethicus			0/16				
Microtus montanus		0/3				0/4	0/2
Mus musculus							0/1
Erethizon dorsatum				0/4	0/3	0/3	
Canis latrans		0/2				1/2	
Vulpes macrotis					0/2		0/1
Taxidea taxus			0/2	0/1			
Spilogale gracilis					0/2		
Lynx rufus							
Felis catus						0/6	0/1
Odocoileus hemionus						0/10	
Total	0/728	2/2019	0/1392	6/1782	11/2860	13/2481	32/2389

TABLE 6. INCIDENCE OF Q FEVER POSITIVE SERA ACCORDING TO AREA. Areas from which wildlife specimens were collected that produced Q fever complement fixing antibody titers of 1:16 or higher. Shown as the number positive over the number collected.

Area	1954	1955	1956	1957	1958	1959	1960
Callao	0/0	0/50	0/235	0/168	4/94	39/371	34/152
Camelback Mountain		0/4	0/80		2/78	2/84	46/147
CD 22		0/2			4/86	1/20	15/67
Deep Creek	0/4			0/3	0/9	1/1	17/48
Dugway Mountain	0/5	0/1				0/18	13/57
Dugway Valley					8/73	3/53	6/30
Fish Springs	0/13	0/66	0/18	0/58	2/49	10/49	20/73
Gold Hill	0/8	0/74	0/161	0/165	4/139	23/154	21/102
Government Creek	1/7	1/46	0/67	0/87	13/221	39/262	37/179
Granite Mountain	0/68	0/5	0/3		0/29	0/36	10/48
Johnson Pass				0/17	2/72	15/107	0/2
Little Davis Mountain		0/89	0/53	0/154	3/97	8/100	20/60
Lookout Pass						2/45	8/77
North Skull Valley			0/75	0/29	8/217	12/125	48/133
Old River Bed			0/2	1/59	1/206	10/89	27/62
South Cedar Mountain	0/12	0/321	0/40	10/184	11/418	4/53	21/236
South Skull Valley		0/91	0/70	0/176	0/15	3/34	19/66
Test Grid	0/13	0/24	0/8	13/124	3/105	0/11	13/66
Trout Creek		0/4		0/4	1/12	10/42	71/217
Vernon		0/5			0/59	2/47	0/37
Wendover					16/436	57/299	47/229
Wig Mountain	0/27	0/76	0/164	0/45	2/31	2/92	14/58
Wildcat Mountain					1/24		3/38
Outlying areas						18/200	22/86
Totals	1/157	1/858	0/976	24/1273	85/2470	271/2292	532/2265

Creek, Fish Springs, and Wendover had the highest percentage of positive sera. These were 23.8%, 20.4% and 19.1%, respectively. These three areas have been used heavily for domestic grazing in excess of 75 years. In 1960, 21 of the 23 areas sampled exhibited Q fever CF antibodies in animal sera. In 19 of these areas, 20% or more of the serum samples were positive. The majority of these areas were in heavily grazed regions south of DPG, and to the west along the east bench of the Deep Creek Mountains, and north to Wendover.

Wildlife species showing CF antibodies against C. burnetii are listed in Table 7. All species that were obtained in numbers of 10 or more during the 7-year period, except Microdipodops megacephalus, had CF antibodies against Q fever rickettsiae.

Although experimental evidence presented in Section 1 of Results indicates titers as low as 1:16 may not be definitive, they are still used in the tables of this report for comparative purposes. Since the beginning of the project, titers of 1:16 or greater were arbitrarily set as indicative of Q fever infection. Therefore, in order to compare recent work with the original work, the contract requires the recording of titers in a similar manner.

Seven hundred seventy-four pools, composed of 41,215 ectoparasites, were studied from 1954 to 1957 for evidence of C. burnetii. Fleas, mites, and lice were negative, but two pools of ticks of the species Dermacentor parumapertus proved positive (Table 8). Data concerning Q fever organisms in ectoparasites collected since 1957 are shown in Table 9. In 1958 none of the pools contained these rickettsiae, but in 1959 two pools of fleas and one pool of mites produced evidence of the rickettsiae. In 1960 all of the groups of ectoparasites had some pools that were positive for Q fever organisms.

TABLE 7. SPECIES WITH Q FEVER POSITIVE SERA. Wildlife species possessing Q fever complement fixing antibodies of 1:16 or greater. Experssed as the number positive over the number collected.

Species	1954	1955	1956	1957	1958	1959	1960
Lepus californicus	1/55	1/162	0/323	0/270	11/220	61/401	154/378
Sylvilagus nuttallii		0/0	0/1			1/5	0/1
S. audubonii		0/2	0/1		0/6	5/25	8/40
Citellus townsendii		0/2					0/4
C. variegatus		0/2					0/3
C. leucurus	0/2	0/99	0/19	1/55	3/192	7/198	17/245
Eutamias minimus	0/1	0/10		1/5	0/41	0/32	0/17
E. dorsalis	0/1	0/1			0/11	3/18	1/27
Thomomys bottae					1/1		1/1
Perognathus longimembris					1/41	2/64	8/58
P. parvus		0/10	0/5	0/12	0/73	15/74	10/113
P. formosus	0/44	0/5		0/15	1/60	1/57	1/110
Microdipodops megacephalus				0/2	0/12	0/5	0/9
Dipodomys ordii	0/2	0/194	0/19	16/309	15/431	26/227	37/214
D. microps	0/9	0/66	0/53	5/167	24/550	20/229	122/327
Reithrodontomys megalotis			0/9	0/1	1/50	10/94	7/44
Peromyscus crinitus	0/21	0/20	0/8	0/33	0/31	3/75	7/24
P. maniculatus	0/18	0/207	0/493	0/324	25/662	98/577	126/499
P. truei		0/3	0/7	0/8	0/21	5/124	11/67
Onychomys leucogaster				1/5	1/8	1/6	1/6
Neotoma lepida	0/4	0/75	0/36	0/61	2/83	5/43	15/53
N. cinerea				0/2	0/1	0/1	
Ondatra zibethicus						0/1	
Microtus montanus						0/4	0/2
Mus musculus						0/1	1/1
Erethizon dorsatum	0/1	0/1	0/4	0/1	0/1		
Canis latrans						1/3	0/1
Vulpes macrotis					0/1		2/2
Taxidea taxus		0/1				0/4	
Spilogale gracilis					0/1		
Lynx rufus						0/3	
Felis catus						0/6	
Odocoileus hemionus					0/2	7/13	3/17
Totals	1/157	1/858	0/976	24/1273	85/2470	271/2292	532/2265

TABLE 8. Q FEVER IN ECTOPARASITES (1954 to 1957). Kinds and numbers of ectoparasites from native mammals tested for prevalence of Coxiella burnetii during 1954 through 1957.

Ectoparasite	Number tested	Pools tested	Pools containing C. burnetii
Dermacentor parumapertus	19,717	398	2
Dermacentor nymphs	5,111	130	0
Nymphs and larval ticks	3,972	27	0
Larval ticks	5,467	65	0
Haemaphysalis leporis-palustris	10	2	0
Otobius lagophilus	287	18	0
Ixodes kingi	5	2	0
Dermacentor andersoni	1	1	0
Fleas	2,709	67	0
Lice	2,491	43	0
Mites	1,445	21	0
Total	41,215	774	2

TABLE 9. Q FEVER IN ECTOPARASITES (1958 to 1960). Pools of four groups of ectoparasites that were tested for the presence of Q fever rickettsiae. Shown as the number of positives over the number of pools tested. The total number of ectoparasites is also listed.

	Fleas		Ticks		Mites		Lice	
Year	No.	Pos/Pools	No.	Pos/Pools	No.	Pos/Pools	No.	Pos/Pools
1958	2332	0/66	2673	0/68	1062	0/14	2620	0/40
1959	3220	2/100	4496	0/127	2122	1/52	1303	0/38
1960	3085	6/112	5699	9/184	1360	2/29	1665	1/38
Total	8637	9/278	12868	9/379	4544	3/95	5568	1/116

DISCUSSION

The first evidence of Q fever in local wildlife was obtained from seropositive jack rabbit serum collected near the southeast border of Dugway Proving Ground on Government Creek, shortly after the systematic sampling program was initiated in the fall of 1954. The following year another seropositive rabbit was collected from the same area. In addition, C. burnetii isolations were made from tissues of deer mice collected from Camelback Mountain to the west, and from Little Davis Mountain to the east of the site of the first seropositive collections. Q fever organisms were also isolated from a pool of rabbit ticks collected near the north end of Wig Mountain. In 1956 no evidence of Q fever was obtained from the 1,732 wildlife samples collected and tested. During 1957 evidence of Q fever antibodies was also found in two of these same areas, and in one additional area. In analyzing these data, Stoenner et al, (1959) state that during March, April and May of 1957, major epizootics apparently began, based on 30% positive titers in 75 serum samples collected during these months.

During 1958, 11 isolations were made from the tissues of 2,000 wildlife specimens. Eighty-five serum samples from this annual sample had complement fixing antibodies against C. burnetii. The following two years, although the total samples collected were around 400 less, both isolations from tissues and ectoparasites and Q fever complement fixing antibody titers increased.

The means by which Q fever is spread among rodents is unknown, although there is some indication that ticks may act as vectors since this organism has been isolated from them repeatedly. Ticks may also be natural reservoirs since they retain rickettsiae after an infective meal throughout their normal life span, However, in our laboratory, transmissions did not occur when infected ticks fed on normal hosts. Other ectoparasites may be incidentally infected, but probably play no major role in the epizoology of Q fever.

All the rodent hosts are highly susceptible to Q fever infection and retain significant complement fixing antibodies against Phase II antigen (egg-adapted) throughout their normal lives. Rodents also retain rickettsiae for some time after infection and may not be completely disregarded as significant carriers of the organism. It has not been shown experimentally, but there is a possibility that this organism, unlike tularemia, may be reservoired in native wildlife as a latent infection. Carnivores are not as susceptible as rodents and probably play a minor role in the epizoology of the disease through feeding on the infected rodents, or possibly contracting the organisms from infected vectors or infected dust.

Since Q fever is fairly widespread according to areas, and since ticks were not positively incriminated as efficient transmitters, while the rodents are highly susceptible to subcutaneous and aerosol infection, it is possible that Q fever may be transmitted among rodent populations without arthropod vectors. This may occur by animal to animal contact, infected dust, or even possibly through ingestion of infective flesh.

Even less well known than the wildlife epizoology of Q fever is the disease relationship of the wildlife and livestock that have inhabited the same areas in western Utah since 1875. Certainly one could expect a wildlife-domestic animal relationship, particularly during seasonal parturition on open range lands inhabited by both.

There is no reason to believe that Q fever was not present among mammalian populations of DPG prior to 1954. On the contrary, since Q fever has been noted as a disease of domestic animals in the United States, the infection would be expected among wildlife wherever sheep or other livestock are grazed for any length of time. Whether or not there is a wildlife reservoir of C. burnetii separate and apart from a livestock reservoir remains a moot question.

In light of these data there are at least three probable explanations of the distribution of Q fever:

1) The first is that this disease was enzootic in this area and did not reach increased proportions until 1957. Supporting this premise that Q fever is enzootic in the wildlife of the United States is an epizoological survey in Texas (Irons et al, 1952), in which CF antibodies for C. burnetii were reported in wood rats, Neotoma micropus; and in California, where Lechleitner (1959) reported serological titers in jack rabbits. This organism has been isolated from ticks that are commonly found on native animals throughout many areas of the United States. It is not surprising that it has been found in the wildlife of the United States, since Q fever has been reported in wildlife throughout many other areas of the world (Stoker and Marmion, 1955b). In fact, Perez et al, (1952) suggest that wild mice and rabbits are reservoirs of Q fever in Spain.

2) The second explanation is that the disease became artificially established in the test area some time prior to 1954 and spread rather rapidly in a susceptible wildlife population. The latter premise, however is discredited by Stoenner et al, (1959) since the strains isolated from wildlife differed from the experimental strains, and because the first isolations were in excess of 20 miles from field test areas.

3) The third premise is that wildlife infection resulted from infected livestock occupying the same habitat or range land over a long period of time. Supporting this premise is the locations of both the first positive wildlife samples and the areas exhibiting the greatest degree of infection. The former all occurred adjacent to sheep and cattle range or bedding areas,

just inside the fenced area of Dugway Proving Ground. The latter occurred for the most part some 40 miles to the west, in areas that have been heavily grazed with livestock for decades.

Since none of the premises can be completely validated in the light of the present dats, further studies on the distribution and isolation of this organism should be pursued beyond the present known range of infection. Certainly isolation and characterization of strains outside this area would be a most logical approach to properly evaluate the foregoing question and would add appreciably to the meaning of the data. Studies on the disease relationships between wildlife and livestock should also be undertaken.

Regardless of which premises may prove most valid, the fact remains that Q fever is well established in the wildlife of this area. Since it is widely distributed, introduction by experimentation will probably not greatly alter the present epizoology. In fact, serological results indicate there may be a degree of immunity in wildlife, suggesting the incidence may soon subside, or is now subsiding.

CONCLUSIONS

1. Coxiella burnetii exists in the wildlife of the northwest part of the State of Utah.
2. The common native rodents were shown to be very susceptible to both parenteral inoculation and aerosol exposure.
3. The methods outlined in the protocol for this organization are satisfactory for determination of Q fever in wildlife, with the exception that only complement fixation titers of 1:32 or greater are reliable evidence of infection.
4. Native ticks readily became infected with C. burnetii when feeding on infected hosts, but transmission to healthy hosts was not demonstrated in our laboratory.
5. The first evidence of Q fever in wildlife and the highest infection rate occurred in specimens obtained near livestock grazing areas.
6. In some of the sampling areas, the abundance of animals showing CF antibodies may indicate that a degree of immunity may be developing in wildlife.
7. Q fever studies in the environs of Dugway Proving Ground will not alter the present epizoology of the disease.

BIBLIOGRAPHY

Babudieri, R. and G. Moscovici. 1952. Experimental and natural infection of birds by Coxiella burnetii. Nature. 169:195-196.

Bektimirov, T. A., I. V. Tarasevich, and B. E. Karulin. 1956. A study of an epidemic focus of Q fever in Crimea. Shur.Mikrobiol., Epidemiol. i Immunobiol. Moscow. No.11:20-26. (Trop. Dis. Bull. 54:533, 1957).

Blanc, G. and J. Bruneau. 1949. Un reservoir de virus de la Q fever en Algerie, la tique bovine, Hyalomma mauriticanicum. Bull. Acad. Nat. Med. (Paris). 133:115-117. (Ex. Med. IV. 2:4180, 1949).

Blanc, G. and J. Bruneau. 1953. Entretien dans la nature de Coxiella burnetii par l' association du lapin de garenne Oryctolagus cuniculus (L.) et de la tique Hyalomma excavatum (C.K.). C. R. Acad. Sci. 237:582-584.

Blanc, G. and J. Bruneau. 1955. Ornithodoros et Coxiellose (Q fever). C. R. Acad. Sci. 240:129-133.

Blanc, G. and J. Bruneau. 1956a. Isolement du virus de Q fever de deux rongeurs sauvages procenant de la foret da Nefifik (maroc.). Bull. Soc. Path. Exot. 49:431-434.

Blanc, G. and J. Bruneau. 1956b. An epidemiological and ecological study of Nefifik Forest. I. Presence in the wild rabbit and its biting arthropods of viruses pathogenic to man. Arch. Inst. Pasteur. du Maroc. 5:87-200. (Trop. Dis. Bull. 54:556, 1957).

Blanc, G. and J. Bruneau. 1956c. Injection mixte d' Ornithodoros erratum (Lucas) over spirochete (Borrelia hispania) et rickettsiae (Coxiella burnetii). Technique de separation des germes. C. R. Acad. Sci. (Paris). 242:1376-1377.

Blanc, G. and J. Bruneau. 1957. Presence chez une chauve (bat) souris du Maroc. Eptesicus isabellinus (Temminch) d' un virus de Q fiebre. Bull. Soc. Path. Exot. 50:653-656.

Blanc, F., J. Bruneau and A. Chabaud. 1950. The presence of Rickettsia (Coxiella) burneti in ticks of the species Amblyomma variegatus obtained from French Equatorial Africa. C. R. Acad. Sci. 230:474-475.

Blanc, G., J. Bruneau, R. Poitrot, and B. Delage. 1948. Quelques donnees sui la Q fever (maladie de Derrick-Burnet) experimentale. Bull. Acad. Nat. Med. (Paris). 132:243-250. (Ex. Med. IV. 1:5280. 1948).

Blanc, G., L. A. Martin and A. Maurice. 1946. Sur une rickettsia isoles de tique dans le Sui marocaine. Son identite probable avec Rickettsia burneti, agent de la Q fever. C. R. Acad. Sci. 223:438-439.

Blanc, G., L. A. Martin and A. Maurice. 1947a. Le merion (Meriones shawi) de la region de Goulimine est un reservoir de la "Q fever" marocaine. C. R. Acad. Sci. 224:1673-1674.

Blanc, G., L. A. Martin and A. Maurice. 1947b. Presence du virus de la Q fever dans la maroc meridional. Bull. Acad. Nat. Med. (Paris). 131: 138-143. (Ex. Med. IV. 1:2185. 1948).

Borizov, V. D., I. K. Karskulov and S. A. Amenshulov. 1959. The present state and future prospects for studies on Q fever in Kazakhstan. Jour. Microbiol., Epidemiol., i Immunobiol. Moscow. 30:83-89.

Carley, J. C. and J. H. Pope. 1953. The isolation of Coxiella burneti from the tick, Ixodes holocyclus in Queensland. Austral. J. Exper. Biol. Med. Sci. 31:613-614.

Cox, H. R. 1938. A filter-passing infectious agent isolated from ticks. III. Description of organisms and cultivation experiments. Pub. Hlth. Rept. 53:2270-2276.

Cox, H. R. 1940. Rickettsia diaporica and American Q fever. Amer. J. Trop. Med. 20:463-469.

Davis, G. E. 1940. Rickettsia diaporica: its persistence in the tissues of Ornithodoros turicata. Pub. Hlth. Rept. 55:1862-1864.

Davis, G. E. 1943. American Q fever: experimental transmission by the argasid ticks Ornithodoros moubata and O. hermsi. Pub. Hlth. Rept. 58:984-987.

Davis, G. E. and H. R. Cox. 1938. A filter-passing isolation from Dermacentor andersoni, reactions in animals and filtration experiments. Pub. Hlth. Rept. 53: 2259-2267.

DeMattia, R., G. C. Angela and G. Turletii. 1952. Experimental studies on the organotropism and elimination of Coxiella burneti. Arch. Sci. Med. 93:483-492. (Ex. Med. IV:1235. 1953).

Derrick, E. H. 1937. Q fever, a new fever entity: clinical features, diagnosis and laboratory investigation. Med. J. Australia. 2:281-299.

Derrick, E. H., D. W. Johnson, D. J. W. Smith, and H. E. Brown. 1938. Susceptibility of dogs to Q fever. Austral. J. Exp. Biol. Med. Sci. 16:245-248.

Derrick, E. H. and D. J. W. Smith. 1939. Annual report of the Health and Medical Services of the State of Queensland, Brisbane. Page 84. Queensland Health and Medical Services Dept. of Health and Home Affairs. (Cited by Stoker and Marmion, 1955a).

Derrick, E. H. and D. J. W. Smith. 1940. Studies in the epidemiology of Q fever. 2. The isolation of three strains of Rickettsia burneti from the bandicoot, Isodon torosus. Austral. J. Exper. Biol. Med. Sci. 18:99-102.

Derrick, E. H., D. J. W. Smith and H. E. Brown. 1940. Studies in epidemiology of Q fever. 6. The susceptibility of various animals to Q fever. Austral. J. Exper. Biol. Med. Sci. 18:409-413.

Derrick, E. H., D. J. W. Smith, H. E. Brown and M. Freeman. 1939. The role of the bandicoot in the epidemiology of "Q" fever; a preliminary study. Med. J. Austral. 1:159-165.

Dyer, R. E. 1939. Similarity of Australian "Q" fever and a disease caused by an infectious agent isolated from ticks in Montana. Pub. Hlth. Rept. 54:1229-37.

Freeman, M., E. H. Derrick, H. E. Brown, D. J. W. Smith and D. W. Johnson. 1940. Studies in the epidemiology of Q fever. V. Surveys of human and animal sera for Rickettsia burneti agglutinins. Austral. J. Exper. Med. Sci. 18:193-197.

Giroud, P. 1951. Les rickettsioses on Afrique Equatoriale. Bull. WHO. 4:535-546.

Heisch, R. B. 1960. The isolation of Rickettsia burneti from Lemniscomys sp. in Kenya. East African Med. J. 37:104. (Trop. Dis. Bull. 57:801. 1960).

Hengle, Von R., G. A. Kausche and E. Sheris. 1950. Über zwei dörfliche Q fieberepidemien in Baden. Duet. Med. Wochschr. 75:1505.

Hesdorfer, M. B. and J. A. Duffaloe. 1941. American Q fever: report of a probable case. J. Amer. Med. Assoc. 116:1901-1902.

Irons, J. V., R. B. Eads, C. W. Johnson, O. L. Walker and M. A. Norris. 1952. Southwest Texas Q fever studies. J. Parasitol. 38:1-5.

Irons, J. V., N. H. Topping, C. C. Shepard and H. R. Cox. 1946. Outbreak of Q fever in the United States. Pub. Hlth. Rept. 61:784-785.

Jadin, J. 1951. Les rickettsioses du Congo Belge et du Ruanda-Urandi, Louvain. Thesis. (Trop. Dis. Bull. 48:897. 1951).

Jellison, W. L., R. A. Ormsbee, M. D. Beck, R. J. Huebner, R. R. Parker, and E. J. Bell. 1948. Q fever studies in Southern California. IV. Occurrence of Coxiella burneti in the spinose ear tick, Otobius megnini.

Kohls, G. M. 1948. Vectors of rickettsial diseaaes. IN: AAAS. Rickettsial Diseases of Man, p. 83.

Lechleitner, R. R. 1959. Some parasites and infectious diseases in a black-tailed jack rabbit population in the Sacramento Valley, California. Calif. Fish and Game. 45:83-92.

Lisunkina, V. A. 1960a. Results of an investigation of certain species of ticks with regard to infection with Rickettsia burneti in Uzliekistan. J. Microbiol., Epidemiol., Immunobiol. 31:930.

Lizunkina, V. A. 1960b. Isolation of Rickettsia burneti from bats in Tashkent. J. Microbiol., Epidemiol. Immunobiol. 31:924-925.

Luoto, L. 1960. Report on the nationwide occurrence of Q fever infections in cattle. Pub. Hlth. Rept. 75:135-140.

Mantovani and Benazzi. 1953. The isolation of Coxiella burneti from Rhipicephalus sanguineus on naturally infected dogs. J. Amer. Vet. Med. Assn. 122:117-119.

Marmion, B. P. 1954. Natural history and epidemiology of Q fever in man. Trans. Roy. Trop. Med. Hyg. (Lond.). 48:197-207.

Marmion, B. P. 1959. Q fever: recent developments and some unsolved problems. Proc. Roy. Soc. Med. 52:613-616.

Nikhinson, I. M., I. B. Kamur and E. N. Savchenko. 1958. Q fever on Sakhalin. J. Microbiol., Epidemiol., Immunobiol. 29:215-218.

Noguchi, H. 1926. A filter-passing virus obtained from Dermacentor andersoni. J. Exptl. Med. 44:1-10.

Parker, R. R., E. J. Bell, and H. G. Stoenner. 1948. Q fever: a brief survey of the problem. J. Amer. Vet. Med. Assn. 115:55-60.

Parker, R. R. and G. E. Davis. 1938. A filter-passing infectious agent isolated from ticks. II. Transmission by Dermacentor andersoni. Pub. Hlth. Rept. 53:2267-2270.

Parker, R. R., J. Deprada, E. J. Bell, and D. B. Lackman. 1949. Recovery of Coxiella burneti from Hyalomma savignyi collected in Spain. Pub. Hlth. Rept. 64:1616-1618.

Parker, R. R. and G. M. Kohls. 1943. American Q fever: The occurrence of Rickettsia diaporica in Amblyomma americanum in eastern Texas. Pub. Hlth. Rept. 58:1510-1511.

Parker, R. R. and E. A. Steinhaus. 1943. American and Australian Q fever: persistence of the infectious agents in guinea pig tissues after defervescence. Pub. Hlth. Rept. 58:523-527.

Parker, R. R. and O. Sussman. 1949. Spontaneous infection of the brown dog tick, Rhipicephalus sanguineus, with Coxiella burnetii. Pub. Hlth Rept. 64:1159-1160.

Payzin, S. and N. Array. 1952. Natural occurrences of Coxiella burneti in Ornithodoros lahorensis ticks. Turk Ijien. Tecrubi Biol. Dergisi.

Pchelkina, A. A., Z. M. Zhmaeva and R. I. Zubikova. 1956. Q fever in northern Kasakhastan. Zhur. Mikrobiol., Epidemiol., Immunobiol. Moscow. No. 11:32-35. (Trop. Dis. Bull. 54:554, 1957).

Perez Gallardo, F., G. Clavero, and F. S. Hernandez. 1949. Detection of Coxiella burneti (the agent of Q fever) in Spain. Rev. Sanidad e Hig. Publ. (Madr.). 23:489-495.

Perez Gallardo, F. G. Clavero, and F. S. Hernandez. 1952. Epidemiological studies of Q fever in Spain. Mountain rabbits and dormice as reservoirs. Trop. Dis. Bull. 50:924.

Pizzi, M. 1950. Sampling variation of the fifty per cent end-point determined by the Reed-Muench method (Behrens). Human Biol. 22:151-190.

Pope, J. H. W. Scott and R. Dwyer. 1960. Coxiella burneti in kangaroos and kangaroo ticks in western Queensland. Austral. J. Exptl. Biol. Med. Sci. 38:17-28.

Proreshnaia, T. L. and N. K. Meshchenko. 1958. A study of a focus of Q fever in the Issyk-Kul'sk District of the Kirghiz SSR. J. Microbiol., Epidemiol., Immunobiol. 29:218-223.

Raska, K. and L. Syrucek. 1956. Ein beitrag sur epidemiologie der Q-ricksiosy der Q-rickettsioses. Zentralol. Bakt. I. Abt. Orig. 167: 267-280.

Raska, K., L. Syrucek, O. Sobeslavsky, J. Pokorny, M. Privora, O. Havlik, D. Lim, and M. Zastera. 1956. The participation of rodents in the epizoology of Q-rickettsioses. Ceskoslov. Epidemiol., Mikrobiol., i Immunobiol. Prague. 5:246-250. (Trop. Dis. Bull. 54:280. 1957).

Reczko, E. 1950. The excretion and maintenance of Q fever rickettsia in experimentally infected guinea pigs. Zent. Bakt. Abt. I. Orig. 156:81-84.

Rehn, F. 1958. Experimental infection of the fox (Vulpes vulpes) and the forest mouse (Apodemus flavicolis) with the causative agent of Q fever. Ceskoslov. Epidemiol., Mikrobiol., i Immunobiol. Prague. 7:317-320. (Trop. Dis. Bull. 56:29. 1959).

Rehn, F. and R. Radvan. 1959. Isolation of Coxiella burnetii from the common shrew mouse, Sorex araneus, caught in the focus of Q fever in northeastern Bohemia. Ceskoslov. Epidemiol., Mikrobiol., i Immunobiol., Prague. 8:49-51. (Trop. Dis. Bull. 56:604, 1959).

Shepard, C. C. 1947. An outbreak of Q fever in a Chicago packing house. Amer. J. Hyg. 46:185-192.

Smith, D. J. W. 1940. Studies in the epidemiology of Q fever. 3. The transmission of Q fever by the tick Haemaphysalis humerosa. Austral. J. Exptl. Biol. Med. Sci. 18:103-118.

Smith, D. J. W. 1941. Studies in the epidemiology of Q fever. 8. The transmission of Q fever by the tick Rhipicephalus sanguineus. Austral. J. Exptl. Biol. Med. Sci. 19:133-136.

Smith, D. J. W. 1942. Studies in the epidemiology of Q fever. 10. The transmission of Q fever by the tick Ixodes holocyclus (with notes on tick-paralysis in bandicoots). Austral. J. Exptl. Biol. Med. Sci. 20: 213-217.

Smith, D. J. W. and E. H. Derrick. 1940. Studies in the epidemiology of Q fever. I. The isolation of six strains of Rickettsia burneti from the tick Haemaphysalis humerosa. Austral. J. Exptl. Biol. Med. Sci.18:1-8.

Sobeslavsky, O. and L. Syrucek. 1959. Transovular transmission of Coxiella burneti in the domestic fowl (Gallus gallus domesticus). J. Hyg. Epidem. Microbiol., i Immunobiol. Prague. 3:458-464. (Trop. Dis. Bull. 57:697, 1960).

Sterkhova, N. N. and M. G. Akhundov. 1959. Role of wild rodents in the epidemiology of Q fever. J. Mikrobiol., Epidemiol., and Immunobiol.30:153-154.

Stoenner, H. G., R. Holdenried, D. Lackman, and J. S. Orsborn, Jr. 1959. The occurrence of Coxiella burneti, Brucella and other pathogens among the fauna of the Great Salt Lake Desert in Utah. Amer. J. Trop. Med. Hyg. 8:590-596.

Stoker, M. G. P. and B. P. Marmion. 1955a. The spread of Q fever from animals to man. The natural history of rickettsial diseases. Bull. WHO. 13:781-806.

Stoker, M. G. P. and B. P. Marmion. 1955b. Q fever in Britain: isolation of Rickettsia burneti from the tick Haemaphysalis punctata. J. Hyg. (Lond.) 53:322.

Strauss, E. and S. E. Sulkin. 1949. Complement fixing antibodies with Coxiella burneti antigens in various geographic areas and occupational groups in the United States. Amer. J. Pub. Hlth. 39:492-503.

Syrucek, L. 1949. (Discussion of Q fever papers). Proc. Roy. Soc. Med. 52:620-621.

Syrucek. L. and K. Raska. 1956. Q fever in domestic and wild birds. WHO. 15:329-337.

Syrucek, L. and O. Sobeslavsky. 1956. Experimental infections in rats (Rattus norvegicus) with Coxiella burneti. Ceskoslov. Epidemiol., Mikrobiol., i Immunobiol. Prague. 5:251-254. (Trop. Dis. Bull. 54:24, 1957).

Syrucek, L., K. Raska, and O. Havlik. 1955. Q rickettsiosy u ptaku Q horrecka. Cesk. Epidemiol., Mikrobiol., i Immunobiol. 4:22-26.

Syrucek, L., O. Sobeslavsky, and O. Havlik. 1957. Isolation of Rickettsia burnetii from the pigmy shrew Sorex minutus, in a focus of Q-rickettsioses in northwestern Bohemia. Ceskoslov. Epidemiol., Mikrobiol. i Immunobiol. Prague. 6:392-395. (Trop. Dis. Bull. 55:386. 1958).

Taylor, R. H., R. A. Mount, H. Hoogstraad, and H. R. Dressler. 1952. The presence of Coxiella burneti (Q fever) in Egypt. J. Egypt Pub. Health Assn. 27:123-128. (Trop. Dis. Bull. 51:788. 1954).

Weyer, F. 1952. Die Besishungen des Q fieber-Enegers (Rickettsia burneti). Zu Arthropoden. Z. Tropen. Med. Parasitol. 43:344-382.

Young, F. M. 1948. Q fever in Artesia, California. Calif. Med. 69:89-90.

Zarnea, C., N. Alexandrescu, L. Szeglix, R. Voiculescu, M. Dinculescu, H. Ionescu, and S. Perederi. 1959. The occurrence of Coxiella burnetii in a hedgehog, Erinaceus europaeus (Linne), captured in an endemic-epizootic focus of Q fever. Arch. Roumaines Path. Exper. et Microbiol. 18:83. (Trop. Dis. Bull. 56:1227, 1959).

Zhmaeva, Z. M., S. E. Karulin, A. A. Pchelkina and M. V. Shchekhanov, 1956. The role of mammals in transmission of Coxiella burneti, the causal organism of Q fever. Doklady Akad. Nauk. SSSR. 109:1227-1228.

Zhmaeva, Z. M. and A. A. Pchelkina. 1957. Domestic birds as carriers of the rickettsia of Q fever in the Turkinen SSR. J. Microbiol., Epidemiol., i Immunobiol. 28:347-349.

Zhmaeva, Z. M., A. A. Pchelkina, N. E. Mishchenko and B. E. Karulin. 1955. The epidemiological importance of ectoparasites in birds of a natural focus of Q fever in the south of Central Asia. Doklady Akad. Nauk. SSSR. 101:387-389. (Trop. Dis. Bull. 53:430, 1956).